

24. The Auditory Bulla and other Cranial Characters in the Mustelidæ. By R. I. Pocock, F.R.S., F.Z.S.

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(Text-figures 14-18.)

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In 1869 (Proc. Zool. Soc. pp. 4-37) Flower described certain features in the base of the skull of several genera of Mustelidæ, especially those connected with the auditory bulla and the adjacent foramina, recording the position of the glenoid, carotid, and condyloid foramina, and noting the shape and relative prominence of the mastoid and paroccipital processes. In many instances he opened the bullæ and described the internal structure. The genera examined were *Lutra*, *Enhydris*, *Meles*, *Taxidea*, *Mephitis*, *Helictis*, *Arctonyx*, *Mydaus*, *Gulo*, *Mellivora*, *Galera*, *Martes*, *Mustela*, and *Rhabdogale* [= *Ictonyx*]. He summarised the results of his examination of the skulls of the Ursidæ, Procyonidæ, and Mustelidæ as follows:—(1) The cavity of the bulla is simple.... That is, although there are frequently trabeculæ or partial septa passing mostly transversely across the lower part, and generally connected with the tympanic ring, there is no distinct and definite septum dividing it into a separate outer and inner character [misprint for chamber]. (2) The paroccipital process is more or less triangular, and directed backwards, outwards, and downwards, standing quite aloof from the bulla. This relation depends chiefly on the want of development of the posterior portion of the bulla; and is absent, or obscure, in *Mustela* alone. (3) The alisphenoid canal is present in the true Bears and *Ailurus*; absent in all the others [*i. e.* in all Mustelidæ].

Although these statements have been copied over and over again in works on the classification of the Carnivora, further investigation shows that not one of them is exact. The bulla of *Helictis*, for example, is as completely divided as in the Felidæ, and there is a very distinct partition in *Grison*, *Gulo*, *Mellivora*, and other genera, although it is not so complete as in the typical *Æluroidea*. As regards the paroccipital process, although its prominence and remoteness from the bulla are well marked in such genera as *Lutra*, *Mephitis*, *Mellivora*, *Meles*, *Taxidea*, and others, it is in *Helictis* and *Grison* as closely applied to the posterior end of the bulla as in typical Felidæ, and it is even more confluent with the bulla in *Pecilictis* than in

Mustela. Flower's statement about the absence of the alisphenoid canal may stand with the qualification that the canal may be retained as an abnormality.

In 1885, Mivart (Proc. Zool. Soc. pp. 363-389) supplemented Flower's observations with a few additional facts and included *Conepatus*, *Pecilogale*, and *Lyncodon* in the list of genera.

Since that date it does not appear that the facts have been re examined. The observations contained in the following pages, based mainly on specimens that have died in the Society's Gardens, may, therefore, be interesting and useful.

The Foramina in the Base of the Skull.

The Alisphenoid Canal.—This tube, as is well known, is typically absent in the Mustelidæ. But in one example of *Lutra lutra*, I find the remnants of it on the left side of the skull although the right side is normal. A little distance in front of the *foramen ovale* and higher up there is a small orifice through which a bristle can be passed so as to appear in the aperture common to the *foramen lacerum anticum* and the *foramen rotundum*. The passage is no doubt the homologue of the alisphenoid canal in the Canidæ, Ursidæ, *Ailurus*, Mungotidæ, etc. Except as an item of evidence supporting the view that the canal in question is a primitive Carnivore feature, the discovery of it in a skull of *Lutra* is of no great moment. As I have elsewhere pointed out, it may be present or absent in the Hyænidæ (Proc. Zool. Soc. 1916, p. 444, fig. 2).

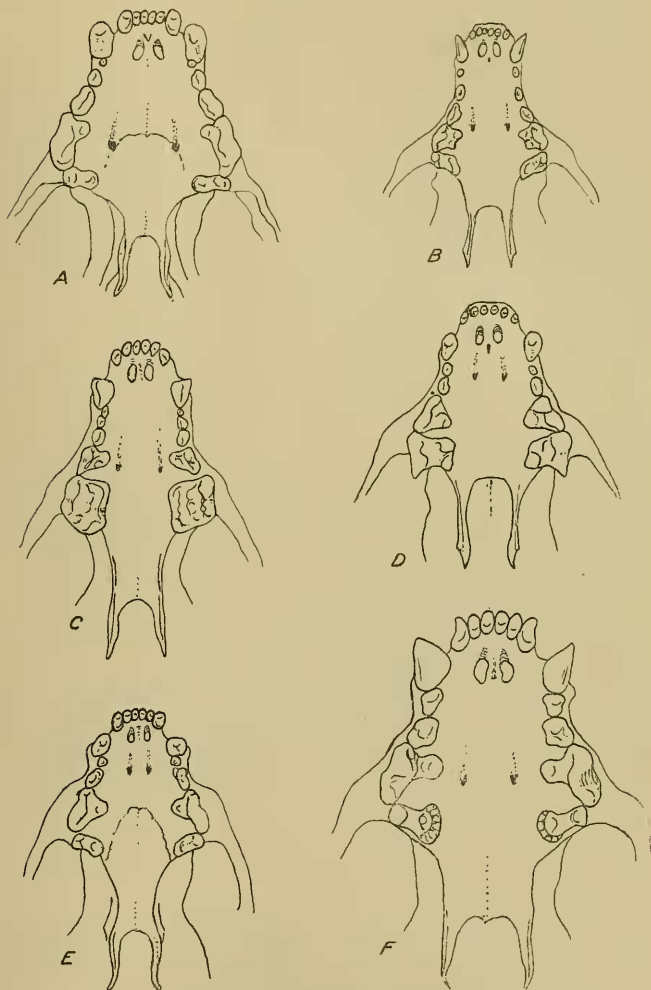
The Posterior palatine foramina.—The normal position of these is approximately opposite the inner lobe of the upper carnassial tooth (*pm.*⁴) on the maxillo-palatine suture, along which they move to a certain extent backwards or forwards. They hold this position in *Martes*, *Charronia*, *Gulo*, *Tayra*, *Mellivora*, *Meles*, *Arctonyx*, *Mydaus*, and *Helictis*. In *Taxidea* they may be as far back even as the anterior edge of the molar. In *Lyncodon*, *Grisson*, *Ictonyx*, *Pecilictis*, *Lutra*, *Pecilogale*, *Vormela*, and *Mustela*, with its related generic and subgeneric forms, *Gale*, *Putorius*, *Lutreola*, they are on the maxilla approximately opposite *pm.* 3 and removed from the maxillo-palatine suture. In *Mephitis*, *Spilogale*, and *Conepatus* they may be even nearer still to the anterior palatine foramina, opposite *pm.* 2.

It may be noticed that in all the genera with long jaws like *Meles*, *Arctonyx*, *Mydaus*, *Helictis*, and *Martes* they are set back on the suture, whereas in some genera with short jaws and often reduced dentition, like *Mustela*, *Vormela*, *Grisson*, and *Lutra*, they are set forwards, wholly on the maxilla. Nevertheless this position is not always correlated with the length of the jaws and teeth, since they occupy the backward position in *Mellivora* and *Taxidea*.

Their variation in position within the Mustelidæ is interesting in view of their constancy in position in other families of

Carnivora. In the Ursidæ, Procyonidæ, Canidæ, and Felidæ they are always placed back upon the suture, whereas in the Hyenidæ,

Text-figure 14.



Palates of *Gulo gulo* (A), *Helictis everetti* (B), *Meles meles* (C), *Mephitis* sp. (D), *Grison* (E), *Mellivora ratel* (F), showing the position of the post-palatine foramina.

Mungotidæ, and the large number of genera usually assigned to the Viverridæ they open on the maxilla in front of the suture;

and in connection with the *Æluroid* (or *Mungotoid*) families cited, it may be noted that the *Felidæ*, which, like *Mustela*, *Grison*, etc., have shorter jaws and the teeth more reduced numerically than in any other *Carnivora*, they are set back, whereas in such relatively long-jawed forms as the typical *Viverridæ* they are wholly maxillary in position.

The Foramen rotundum.—As in the *Canidæ*, this foramen is visibly separated from the foramen lacerum anticum in profile view of the skull in *Martes*, *Charronia*, *Gulo*, *Helictis*, and *Taxidea*; but in *Mustela*, *Putorius*, *Grison*, *Lyncodon*, *Tayra*, *Ictonyx*, *Pæcilogale*, *Mellivora*, *Meles*, *Mephitis*, and *Lutra* it is at most visible as a separate orifice when the orbit is looked into from the front, lying quite close to the foramen lacerum anticum in a depression common to the two. Not uncommonly the two orifices are confluent owing to the failure of the partition to ossify, but within the limits of the genus *Ictonyx* there is individual or racial variation in this particular, and no doubt the same is true of other genera.

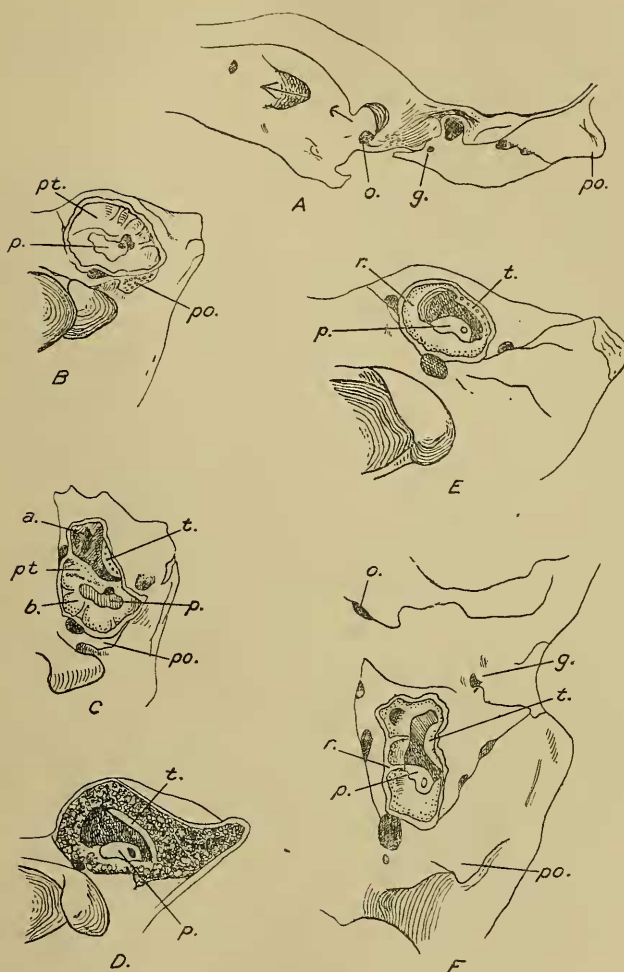
The Foramen ovale.—The position of this foramen with regard to the orifice of the eustachian tube varies in accordance with the length of the back of the skull and with the inflation of the anterior part of the bulla. Typically it is separated by a considerable space from that orifice as in *Mustela*, *Putorius*, *Martes*, *Charronia*, *Gulo*, *Tayra*, *Grison*, *Mellivora*, *Meles*, *Helictis*, and *Lutra*; but in *Ictonyx*, *Pæcilictis*, *Taxidea*, *Mephitis*, *Spilogale*, and *Conepatus* the foramen is only separated from the eustachian orifice by a thin plate of bone.

The Glenoid foramen.—The typical position of this in profile view of the skull is in front of the external auditory meatus either in line with it or slightly higher or lower as the case may be. It is lowest in *Taxidea*, where it is almost below the lower edge of the meatus. In *Meles* it is, on the contrary, almost above the upper edge of the meatus. In *Mustela*, *Martes*, *Charronia*, *Gulo*, *Tayra*, *Mellivora*, *Ictonyx*, *Grison*, and *Lutra* it holds intermediate positions. In *Mephitis*, *Spilogale*, and *Conepatus* it is, however, set right over the middle of the upper rim of the meatus; and in *Helictis* it occupies almost the same position—farther back even than in the *Canidæ*.

When the skull is viewed from below, the position of the foramen also varies with respect to the auditory meatus. In *Helictis*, *Mephitis*, *Spilogale*, and *Conepatus* it is quite concealed behind the rim of the orifice. In *Martes*, *Charronia*, and *Meles* it is just concealed by its anterior rim. In *Mustela*, *Putorius*, *Tayra*, *Ictonyx*, *Grison*, *Taxidea*, and *Mellivora* it is just visible in front of the anterior rim of the orifice. In *Gulo* and *Lutra* it is exposed in front of the tubular meatus, nearly as far inwards as in the *Ursidæ*.

The Stylomastoid foramen.—Typically this foramen lies on the inner side of the mastoid prominence and between it and the inflated portion of the bulla. It is approximately in line with

Text-figure 15.



- A. Part of the skull of *Lutra lutra* showing the abnormal occurrence of the alisphenoid canal indicated by arrow.
- B. Bulla of *Helictis everetti*, the posterior chamber opened from behind showing the partition (*pt.*) descending to the petrous.
- C. The same from below cut open to show the partition (*pt.*) running obliquely between the anterior chamber (*a*) and the posterior chamber (*b*).
- D. Bulla of *Putorius putorius* opened from behind, showing the thickened spongy tissue of the walls and the undivided cavity.
- E. Bulla of *Lutra lutra* showing the partial division of the cavity by rafters.
- F. The same from below.
- Lettering :—*a*, *b*, anterior and posterior chambers of cavity (in B, C); *g*, glenoid foramen; *o*, foramen ovale; *p*, petrous portion of petiotic; *po*, paroccipital process; *pt*, partition (in B, C); *r*, rafter; *t*, edge of tympanic annulus.

the glenoid foramen and some distance from the *foramen lacerum posticum*. Its position varies in accordance with the inflation of the bulla, and every gradation can be traced from *Mustela*, where it is thrust far out, to *Gulo*, *Lutra*, and *Mephitis*, where it lies far in towards the *foramen lacerum posticum*. It is relatively closer to the latter orifice in the Skunks than in other genera.

The Internal Structure of the Auditory Bulla.

The bulla of *Meles meles* may be described as representing a common type in the family*.

The tympanic ring projects far into the cavity of the bulla as a large semicircular lamina. The space between it and the roof of the bulla is divided into chambers by a few vertical, arched, bony plates, arising from the lamina and the superjacent roof and extending transversely inwards on to the inner wall. These may be called the rafters. There is also a tolerably large plate rising from the upper side of the tympanic ring in front and extending horizontally forwards to the bottom of the anterior wall of the bulla, terminating internally at a point where the bulla touches the *foramen lacerum medium*. Behind this point the floor of the cavity is subdivided by low anastomosing ridges into a number of pockets.

The posterior portion of the tympanic ring lies just above the *fenestra rotunda* on the periotic bone; and the posterior rafter, rising about one-fourth of the distance from the posterior end of the tympanic ring, arches high above the periotic and terminates about half-way down the inner wall of the cavity. This rafter, supplemented by the posterior end of the tympanic ring, partially divides the cavity of the bulla into an anterior larger and a posterior smaller chamber. Nevertheless there is a wide passage between them above the periotic bone. The posterior part of the cavity of the bulla is closed behind, and does not extend beyond the limits of the bulla as defined externally.

The bulla of *Martes martes* resembles that of *Meles* in all essential respects, the posterior rafter being well developed; but in *M. foina* all the rafters are less well developed, the posterior being quite short.

In *Charronia flavigula* there is only a single rafter arising from about the middle of the tympanic ring, arching with a strong concave curve to the roof, then descending to the floor along the inner wall of the bulla.

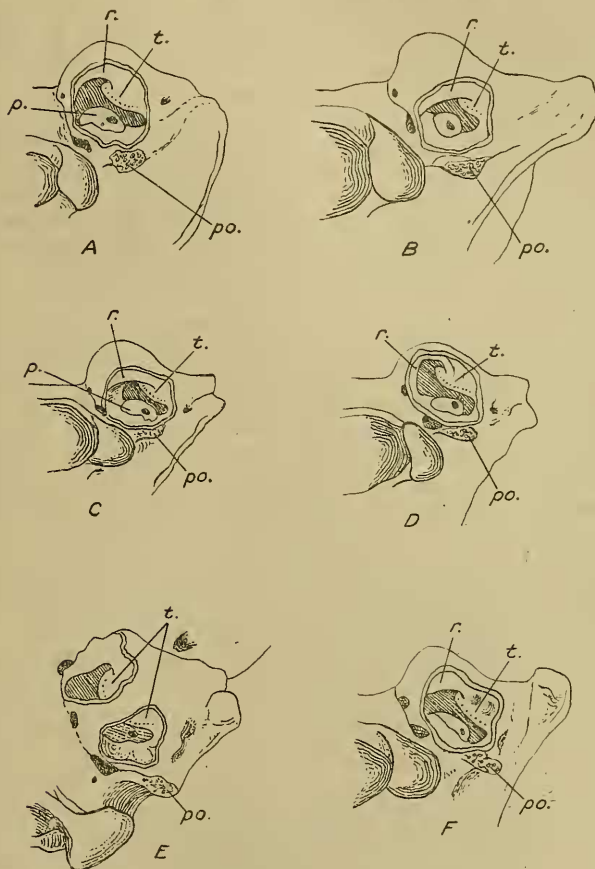
Tayra barbara resembles *Charronia* except that the rafter is less elevated and less arcuate.

Gulo gulo is very like *Meles* and *Martes martes*, but the posterior rafter has the lower edge, not lightly concave as in those

* In this paper the bulla is described as seen when the skull is inverted. Hence the periotic forms part of the floor of its cavity; and the cavity is bounded by the roof above and by the anterior, inner, and posterior walls. Flower described it as seen when the skull is in its natural position, and I followed that course in the case of the Felidæ (Ann. Mag. Nat. Hist. (8) xviii. pp. 326-334, 1916).

forms, but horizontal or inclined slightly downwards towards the inner wall of the cavity. It is thus nearer the periotic bone, and diminishes the height of the passage between the anterior and posterior portions of the bulla.

Text-figure 16.



- A. Bulla of *Tayra barbara* opened from behind.
 B. The same of *Gulo gulo*.
 C. The same of *Martes martes*.
 D. The same of *Martes foina*.
 E. The same of *Meles meles* opened from below in front and behind.
 F. The same from behind.

Lettering as in Text-fig. 15.

Lutra lutra, *cinerea*, *barang*, and *maculicollis* have a very simple type of bulla, differing from those described above in that the tympanic ring, in conformity with the comparative flatness of

the bulla, is almost in contact with the superjacent portion of the roof, to which it is attached by two or three very shallow rafters. The posterior rafter, present in *Meles*, *Gulo*, and *Martes martes*, is undeveloped, the only trace of subdivision of the cavity being supplied by a rafter which extends transversely from the ring along the roof and inner wall of the bulla to a point just behind the orifice of the carotid canal; and, as indicated on the outside of the skull, the cavity of the bulla posteriorly is far in advance of the paroccipital process. Except for its flatness the bulla is very like that of *Tayra* or *Martes foina*.

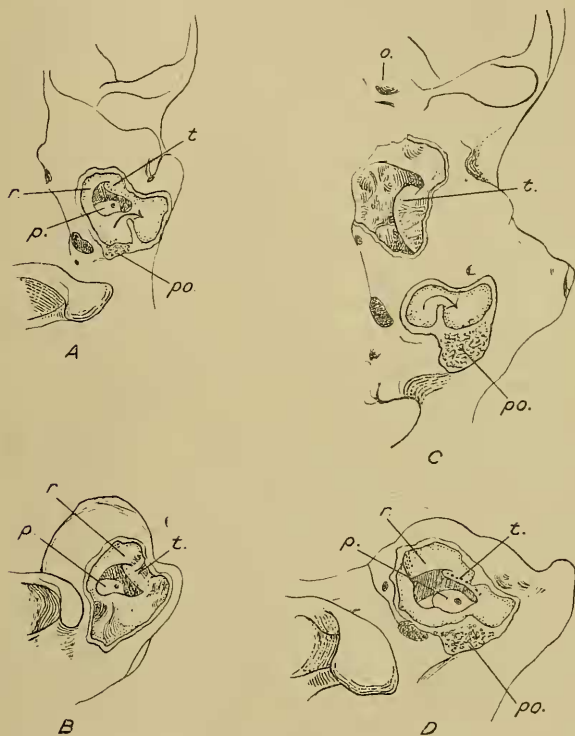
In *Pæcilogale*, judging from a skull with a partially fractured bulla in the British Museum, it seems that the walls of the bulla are thin, not spongy, and that the cavity, reaching posteriorly to the paroccipital, is simple and undivided except by incomplete rafters, and does not communicate with a chamber hollowed out in the mastoid, which is quite small. This genus therefore has a simpler, more primitive bulla than is seen in *Mustela* or in *Ictonyx*.

Another type of bulla is found in *Gale nivalis*, *africana*, *Mustela erminea*, *hibernica*, and *Putorius putorius* and *furo*. The cavity of the bulla is continuous from end to end, being undivided by septa; but it is greatly reduced in size by the thickness of its walls, which, instead of being composed of solid bone, thicker or thinner, as the case may be, in the genera previously described, is composed of spongy bone permeated with air-cells. These fill the entire space above the tympanic ring, and almost obliterate the portion of the cavity behind the petrous portion of the periotic and also the anterior part of the cavity. There is no definite hollow space in the external portion of the periotic; but this bone is spongy and porous like the walls of the bulla itself, and its spaces communicate with the cavity of the bulla.

The bulla of *Helictis* (*H. everetti*) is quite unique. The tympanic ring is fused to the roof but not to the same extent as in *Grissonella* and *Mephitis*, its free edge projecting slightly, even in the middle of its curve, and more so in front and behind. The anterior rafter resembles that of *Grissonella*; but the posterior rafter, rising low down on the tympanic ring behind, runs obliquely forwards and inwards to terminate on the floor of the bulla just inside the point where the orifice of the carotid canal opens. Its inferior edge is closely clamped on to the petrous portion of the periotic except at one point situated externally towards the stylomastoid, where there is a notch in the partition rafter close to the *fenestra rotunda*. Thus the bulla is completely divided into two subequal chambers, except where the notch in question affords a passage between them—a precisely similar formation to that which is well-known in many *Æluroidæ*. The posterior chamber has a few low marginal ridges on its inner and posterior walls, and the anterior end of the anterior chamber has a few ridges in addition to the anterior rafter. The external portion of the periotic is not hollowed.

The bulla of *Mellivora* resembles internally that of *Meles* except that the cavity is posteriorly in communication by means of a tolerably large orifice in the anterior part of the hinder chamber with a smooth-walled cavity hollowed out in the periotic behind the stylomastoid foramen. The posterior rafter is deeper and

Text-figure 17.



- A. Bulla of *Ictonyx* opened from below, the arrow showing the passage between the cavity and the hollow in the external portion of the periotic.
 B. The same of *Paeilictis* opened from behind, showing the extension of the cavity into the occipital and mastoid.
 C. The same of *Mellivora* opened from below, the arrow showing the passage between the cavity and the small hollow in the external portion of the periotic.
 D. The same opened from behind.

Lettering as in Text-figs. 15 and 16.

more arcuate than in *Meles*, and forms a half-partition between the anterior and posterior portions of the cavity of the bulla—and behind it on the inner side a vertical crest of bone juts out from the inner wall of the bulla.

Ictonyx is like *Mellivora* except that there is no crest behind the partition on the inner wall of the bulla; and the related genus *Pacilitis* only differs in the greater size of the supplementary chamber in the periotic and of the space above the tympanic ring.

Taxidea is like *Pacilitis*. In conformity with the great inflation of the bulla the space between its roof and the tympanic ring is very high and septate. The posterior rafter is continuous with the posterior edge of the tympanic ring, and descends so low that only a small passage is left between its inferior arcuate edge and the periotic. A posterior chamber is thus cut off almost as completely as in some *Æluroids*. This posterior chamber is extended anteriorly above the tympanic ring on the inner side of the stylomastoid foramen, and it communicates by a wide passage with a large cavity, larger than in *Mellivora*, hollowed out in the periotic between the mastoid and paroccipital processes.

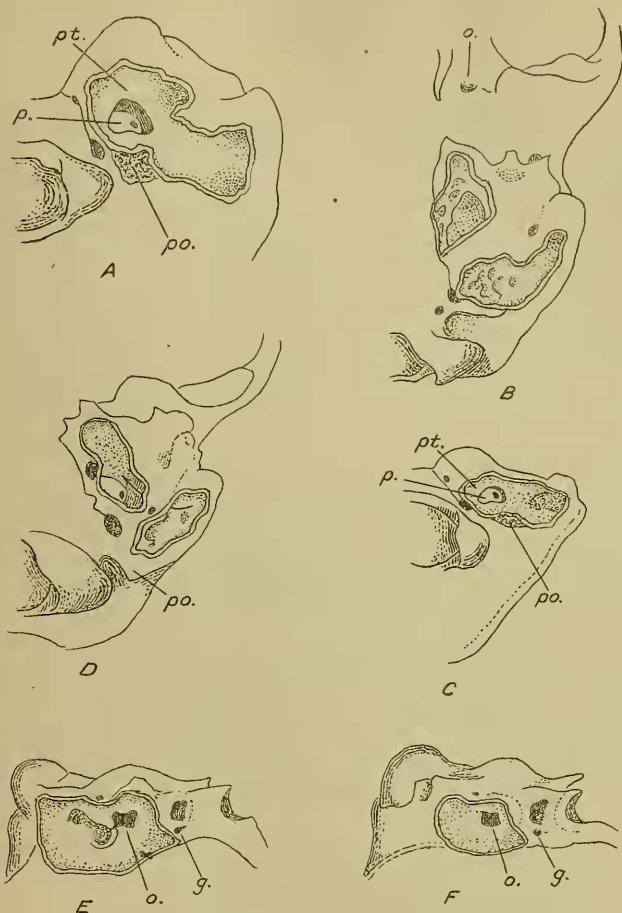
Thus the bulla of *Taxidea* is very different from that of *Meles*, and not essentially like it as Flower stated. It is much more like that of *Mellivora*, although the partition is better developed and the periotic hollow much larger. In *Mellivora*, too, the posterior chamber is not extended forwards above the tympanic ring on the inner side of the stylomastoid.

In *Grissonella* (sp. from Cordova in the Argentine) the roof of the bulla is depressed on to the tympanic ring, and fused with it practically throughout its extent except for the presence of one or two very small cellular spaces in front and behind. The anterior rafter is very large, and rising from the summit of the anterior part of the tympanic ring, descends obliquely downwards and inwards, dividing the anterior part of the cavity, which is further broken up by anastomosing ridges, into an upper and a lower portion. Just behind the posterior end of the ring but confluent with it arises a comparatively large arched rafter which, crossing the roof, descends along the inner wall of the bulla, dividing the cavity into an anterior and posterior chamber which communicate by a comparatively narrow passage above the periotic. The posterior chamber has septa on the inner wall and anastomosing ridges on the floor, and anteriorly just behind the main transverse septum formed by the posterior rafter there is a passage by which the posterior chamber opens into the hollowed external portion of the periotic. The floor of this hollow is uneven with ridges and shallow pits.

It is interesting to note that the bulla of *Grissonella* is widely different from that of *Tayra*, although the two genera were formerly regarded as identical. In possessing a hollowed periotic chamber communicating with the cavity of the bulla, *Grissonella* resembles *Mellivora*, *Ictonyx*, and *Taxidea*, and is further like the latter in the origin of the posterior rafter from the posterior end of the tympanic ring. But in none of these genera is the ring confluent with the roof of the bulla as it is in *Grissonella*.

A skull of *Lyncodon*, with a broken bulla, in the British

Text-figure 18.



- A. Bulla of *Taxidea* opened from behind, showing the nearly complete partition between the posterior and anterior chambers, and the extension of the posterior into the external portion of the periotic.
- B. The same of *Grisonella* sp. opened from below, showing the extension of the posterior chamber into the external portion of the periotic.
- C. The same opened from behind, showing the complete partition and the extension of the posterior chamber into the external portion of the periotic.
- D. Bulla of *Mephitis* opened from below showing the absence of partition, the arrow indicating the passage from the cavity into the hollow of the external portion of the periotic.
- E. Hollow in external portion of periotic of *Mephitis* opened from the outside.
- F. The same of *Conepatus*.

Lettering as in Text-fig. 15, with the addition of *o*, the orifice by which the cavity of the bulla opens into the periotic hollow.

Museum shows that the cavity is broken up by trabeculæ into spaces which extend into the mastoid. It is not possible, however, to ascertain from this specimen whether the cavity, before fracture, was divided by a partition into two chambers as in *Grissonella* or not.

In *Mephitis*, *Spilogale*, and *Conepatus* the bulla is still more peculiar. As in *Grissonella*, the tympanic ring is fused with the roof of the bulla and the cavity of the latter is a hollow space, with at most a few septa or bony ridges, which is closed just behind the periotic by a thickish wall of bone lying between the stylostoid foramen and the *foramen lacerum posticum*; but opposite the outer side of the periotic there is a tolerably large oval orifice by which the cavity of the bulla communicates with a large hollow space occupying the expanded area of the skull between the auditory orifice and a point on the occipital crest above the paroccipital process. Behind the bulla externally there is a tolerably long, flat area running back to the paroccipital process, which, as in *Lutra*, is placed some distance behind the bulla.

In *Mephitis* and *Spilogale* the cavity in the periotic runs inwards by means of a narrow passage up to the *foramen lacerum posticum*, and the posterior margin of the orifice, by which the cavity communicates with the bulla, is produced into a crescentically curved ridge of bone. This ridge and the narrow passage running to the *foramen lacerum posticum* are absent in *Conepatus proteus*, the walls of the cavity being undifferentiated.

In the British Museum there is a skull of *Mydaus* with a broken bulla, which seems to show that in essential points the bulla of this genus resembles that of *Mephitis*. The cavity of the bulla, for instance, comes to an end posteriorly just behind the petrous portion of the periotic, and on the outer side of this bone there is an orifice by means of which the cavity of the bulla communicates with the hollowed mastoid portion of the periotic.

The following table summarises the principal variations in the structure of the bulla :—

- | | |
|---|--|
| a. Cavity of bulla closed behind, not communicating with a hollow space in the external portion of the periotic, the latter being solid or merely permeated with air-cells. | |
| b. Bulla distinctly divided into two subequal chambers by a bony partition running obliquely inwards and forwards from posterior end of tympanic ring to carotid foramen, the two chambers communicating by means of a notch in the lower edge of the partition behind posterior end of petrous portion of periotic | <i>Helictis</i> . |
| b'. At most an incomplete partition passing transversely from posterior portion of tympanic ring to the <i>foramen lacerum posticum</i> . | |
| c. Walls of bulla exceedingly thick, permeated everywhere with air-cells. No partition | <i>Mustela</i> , <i>Putorius</i> , [<i>Vormela</i>]. |
| c'. Walls of bulla thin, without noticeable air-cells. | |
| d. Tympanic ring closely applied to roof of bulla, the posterior end of which is far in advance of the paroccipital. | <i>Lutra</i> . |

- d*. Tympanic ring projecting as a strong semicircular ridge into cavity of bulla and attached to its roof by septa which, rafter-like, pass inwards and downwards along roof and inner wall of the cavity.
- e*. Cavity very incompletely divided by a median rafter arching high above the tympanic ring, leaving a wide space between its inferior edge and petrous portion of periotic *Martes foina*; *Charronia*; *Tayra*.
- e'*. Cavity much more completely divided by an additional rafter, the inferior edge of which extends nearly horizontally inwards and approaches much nearer the petrous portion of the periotic *Martes martes*; *Gulo*; *Meles*.
- a'*. Cavity of bulla opening behind into a larger or smaller hollow space in external part of periotic.
- f*. Cavity undivided, communicating with periotic hollow by means of a well-defined orifice opposite outer side of petrous portion of periotic (tympanic ring fused with roof of bulla).
- g*. Walls of periotic hollow undifferentiated *Conepatus*.
- g'*. Walls of periotic hollow with crescentic ridge and a passage reaching inwards to *foramen lacerum posticum* *Mephitis*, *Spilogale*.
- f'*. Cavity more or less divided by rafter-like partition into an anterior and a posterior chamber, the latter opening into hollow of periotic.
- h*. Tympanic ring fused with roof of bulla; a very narrow space, nearly filled by the periotic between the two chambers; the chambers much broken up by trabeculæ... *Grissonella*.
- h'*. Tympanic ring projecting into bulla, the structure of which closely resembles that described under heading *d'*.
- i*. Periotic hollow smaller, only reaching to a point halfway between paroccipital and tip of mastoid *Mellivora*.
- i'*. Periotic hollow larger, extending to tip of hollow mastoid.
- k*. A bony septum separating posterior chambers of the bulla from periotic hollow behind and leaving a comparatively narrow passage of communication in front; inferior edge of partition between chambers of bullæ evenly concave *Ictonyx*.
- k'*. Posterior chamber of bulla and periotic hollow confluent throughout their extent; inferior edge of partition between chambers angularly arcuate over petrous.
- l*. Bulla abutting behind against nearly obsolete paroccipital and confluent in front with hamular process of pterygoid, as in *Ictonyx* *Pæciliotis*.
- l'*. Bulla not reaching the stout, projecting paroccipital, and ceasing in front far behind hamular ... *Taridea*.

The three genera *Pæcilogale*, *Lyncodon*, and *Mydaus* have been omitted from the table because from want of material my examination of the bullæ was imperfect. So far, however, as the available evidence goes they would fall provisionally as follows:—*Pæcilogale* under *d* alongside *Lutra* because the roof of the bulla is thin and close to the tympanic ring, and its cavity is undivided and not in communication with a hollow in the periotic. The shape of the bulla is, however, very different from that of *Lutra*. It is long, abuts against the paroccipital behind, and has a short auditory tube as in *Mustela*. Its likeness to the bulla of *Lutra* is no evidence of affinity between the two genera.

It merely means, in my opinion, that they have inherited bullæ of a primitive kind, derivable from the *Martes-Tayra* type, the flattening in the two cases having been independently acquired. *Lyncodon* must be provisionally placed alongside *Grissonella*, and *Mydaus* with *Mephitis*, *Spilogale*, and *Conepatus*.

Since such otherwise dissimilar genera as *Meles* and *Gulo* or *Martes* have similar bullæ, it is probable that that type of bulla is the most primitive in the Mustelidæ. The rest of the bullæ may be derived from it by modifications in different directions. The flattening down of the roof on to the tympanic ring and the shortening of the posterior portion of the cavity gave rise to the bulla of *Lutra*; similar flattening of the roof and the development of a complete oblique partition to that of *Helictis*; thickening of the walls with spongy bone filling the spaces between the main septa to that of *Mustela*; and the opening of the posterior chamber into the hollow of the periotic to that of *Mellivora*. From the latter may be derived the bullæ of *Ictonyx*, *Pacilitis*, and *Taxidea* by extension of the periotic space, and in the case of *Grissonella* this was accompanied by the flattening of the bulla and the confluence of its roof with the tympanic ring and reduction of the posterior chamber. The bulla of *Mephitis* and other Skunks may also be derived from the type seen in *Mellivora* by the disappearance of the partition behind the petrous portion of the periotic, shortening of the portion of the cavity behind it, and the forward movement of the orifice by which the cavity communicates with the greatly enlarged periotic hollow.